Are there measures of proven value to reduce nosocomial acquisition of bloodstream infections?

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INTRODUCTION

Nosocomial bloodstream infections are important infections with a high attributable mortality. Prevention of nosocomial bloodstream infections should be aimed at the primary source of the infection. When bloodstream infections are secondary to a source of infection elsewhere in the body, prevention should be aimed at this source. This paper deals with the prevention of primary bloodstream infections which is equivalent to intravascular catheter-related bloodstream infections.

Reliable access to the vascular system has become one of the most essential features of modern medical care. Therefore, approximately 150 million intravascular devices are used annually in the United States. Apart from the benefits of these devices there are several undesirable side-effects. Intravascular devices are the major cause of nosocomial bloodstream infections, which are associated with a 14–28% attributable mortality [1–3]. Although the vast majority of intravascular catheters used are peripheral lines, bloodstream infections are mainly caused by central lines. These infections are largely preventable by adhering to simple and practical guidelines. This paper summarizes those measures which are of proven value in preventing intravascular catheter-related bloodstream infections, and gives some considerations for future developments.

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PATHOGENESIS

There are four major sites where intravascular catheter-related bloodstream infections can arise. First, the insertion site is a major port of entrance. Pathogens can quickly migrate from the skin at the insertion site to the catheter tip along the outer surface of the catheter [4,5]. At the catheter tip microorganisms are incorporated in a bio-film consisting of a thick matrix of glycocalix. This so-called slime layer provides an ideal micro-climate for bacteria and fungi to adhere and grow out. The slime layer protects the microorganisms from the host defense mechanisms and from the activity of antibiotics. The second port of entry is colonization of the hub. Catheter hubs are a common cause of intravascular catheter-related bloodstream infections [6,7]. These two portals of entry are the most frequent causes of intravascular catheter-related bloodstream infections. The relative importance of the insertion site versus the hub may vary in different institutions due to differences in local care during insertion, different duration of catheterization, different types of catheter material and differences in care of the hub. Two other possible mechanisms which are far less frequent in modern settings are hematogenous seeding from a remote focus of infection and contaminated infusate. The latter used to be a frequent cause in earlier days when manufacturing of parenteral medication was less sophisticated. However, currently this problem should be under control.

PREVENTION

Antibiotic prophylaxis during insertion

The few studies which dealt with this issue have shown conflicting results. This, combined with the risk of

widespread resistance associated with such extensive use of prophylactic antibiotics, means that this practice is not recommended [8].

Site of insertion

The internal jugular vein is associated with a higher catheter colonization rate and a higher intravascular catheter-related bloodstream infection rate than the subclavian vein [9–11]. This is probably caused by an increased bacterial colonization density at the internal jugular insertion site and by a more difficult immobilization of the catheter at this site. On the other hand, insertion in the subclavian vein is associated with an increased risk for non-infectious complications, e.g. pneumothorax. The risks of infection of the femoral veins as the insertion site remains controversial [9,10,12].

Precautions during insertion

During insertion of peripheral lines, wearing of sterile gloves is not recommended. Peripheral lines in general have a low risk of infection, certainly when compared with central lines. Several studies have examined the effect of maximal barrier precautions during insertion of central lines. This included the wearing of a mask, cap, sterile gown, sterile gloves and a large sterile drape. All studies showed a significant reduction in the intravascular catheter-related bloodstream infection rate [13–15]. The importance of the level of care during insertion and during follow-up has also been shown by several investigators looking at the effect of a specialized IV-team. Such teams were highly cost-effective in several studies [16]. Furthermore, it has been shown that adequate staffing of nurses for patients with IVD is important to prevent intravascular catheter-related bloodstream infections. Some specific aspects of catheter care during insertion will be discussed below.

Skin antisepsis

The importance of the agent used for skin antisepsis and for subsequent care of the insertion site was demonstrated in a large study by Maki et al. [17]. They found that 2% aqueous chlorhexidine was associated with a significant lower intravascular catheter-related bloodstream infection rate than povidone-iodine 10% or alcohol 70%. Other studies evaluated the effect of adding alcohol to either iodine or chlorhexidine. Both combinations were superior to povidone–iodine [18]. Although clinical studies showing a different in vivo effect of one of the two combinations are lacking, the combination of alcohol and chlorhexidine is preferred because of the superior activity of chlorhexidine compared to povidone–iodine.

Topical antimicrobial ointments

Although this seems an attractive strategy from a theoretical point of view, there have been few well designed studies performed to date. Polyantibiotic ointments were associated with a moderate effect on bacterial colonization rates. Moreover, they were associated with increased candida infection rates. Mupirocin ointment was associated with a lower catheter colonization rate in several studies. No significant effect on the intravascular catheter-related bloodstream infection rate has been demonstrated. Moreover, colonization as an outcome is a difficult item with antimicrobial ointments because they interfere with the reliability of culture results from the catheter tip. In view of these findings and the potential risk of resistance with this application of antibiotics it is currently not recommended [16]. The most interesting studies in this field were done with skin antiseptics, i.e. povidone–iodine ointment. One study found no effect while the other found a fourfold reduction [16]. This strategy aimed at the insertion site is attractive and warrants more extensive investigations.

Dressings

The use of sterile gauze for dressing of the catheter insertion site is more and more replaced by transparent polyurethane dressings. The advantages of transparent dressings are that they permit continuous inspection of the insertion site, they secure the device reliably and are more comfortable to the patient. On the other hand, they are more expensive and it is uncertain what the effect of occlusion of the skin surrounding the insertion site is on the cutaneous microflora. On peripheral catheters a number of studies have been performed. There is some controversy as to whether transparent dressings increase the catheter colonization rate, but the rate of intravascular catheter-related bloodstream infections associated with peripheral lines is so low that both sterile gauze and transparent dressings can be used safely. The more important group are the central vascular catheters. In this group the controversy builds up. Many studies have been performed, resulting in as many different outcomes. The problems are manifold. First, there are several kinds of different dressings and there are several kind of protocols dealing with those dressings. The variations include the method of skin disinfection and the dressing replacement interval. Considering these variations it is difficult to draw final conclusions. For central venous lines it is currently considered to be safe to use transparent polyurethane dressings for prolonged periods. Two recent studies suggest that for arterial catheters transparent dressings may be less safe than sterile gauze and tape [16].

Routine changing of catheters

The risk of infection increases linearly over time. Therefore, the risk for each successive day is no greater than for any previous day. Routine changing of intravascular catheters at certain intervals is therefore not recommended. An exception to this rule may be Swan–Ganz pulmonary artery catheters. The infectious risk of these catheters rises after the fifth day of catheterization and it may therefore not be safe to leave these catheters in place for more than five days.

Changing over a guidewire

Changing a catheter over a guidewire is attractive since it eliminates many non-infectious risks associated with a new puncture site. However, if the site of catheterization is infected there is an increased risk of infection associated with changing over the guidewire. In practice the following strategy is an attractive compromise [16]. When an intravascular catheter is in place for a prolonged period and there is suspicion of infection it is acceptable to change the catheter over a guidewire in the same site. It is mandatory to culture the tip of the catheter which is removed and to take blood cultures. When these cultures show that the catheter was significantly colonized, the new catheter should be removed immediately to prevent the development of a bloodstream infection. In this case a new insertion site is mandatory. When there are local signs of infection at the insertion site or when the patient has symptoms of sepsis it is not recommended to use the guidewire technique but to choose another insertion site initially.

Routine changing of the infusion set

The period for which the infusion system can be in place safely is currently a matter of investigation. For decades the interval considered to be safe has been 24–48 hours. Recent studies showed that 72 hours gave comparable results [19–21], and longer intervals are under investigation. Nowadays, 72 hours is considered to be safe in general. As an exception to this rule, 24-hour intervals are still recommended when blood or blood products have been administered and for lipid emulsions. Longer intervals may further reduce the costs associated with intravascular therapy, but by increasing the interval the chance for significant outgrowth of contaminating micro-organisms increases, thereby increasing the risk for intravascular catheter-related bloodstream infections. The risks for additional prolonging of the interval should be studied carefully before being widely implemented.

In-line filters

In-line filters can have a beneficial effect if the infusate is contaminated. As stated above this kind of contamination is nowadays rare. In addition, these filters should be changed regularly and can become blocked, thereby increasing the number of manipulations of the system and thus enhancing the risk of contamination. Moreover, filters increase the cost of infusion therapy. Therefore, in-line filters are not recommended for routine use.

The hub

The importance of the hub as a source of intravascular catheter-related bloodstream infection is often underestimated. Many hospitals still do not have a written policy for care of the hub [22]. The longer a catheter remains in place, the greater the importance of the hub as a source of contamination [23]. It is important to disinfect the hub when manipulating it. New hubs are being designed aimed at reducing contamination. One hub with an iodine tincture reservoir at the connection site resulted in a major reduction in the intravascular catheter-related bloodstream infection rate [23]. This study was performed in a setting with a remarkably high intravascular catheter-related bloodstream infection rate. The value of this hub in low incidence settings should be investigated. Another development is needle-less connecting systems. Initially these systems were developed to reduce the chance of needlestick accidents. There are currently no studies available on the risk of contamination and infection associated with these systems. Several anecdotal reports have documented a higher intravascular catheter-related bloodstream infection rate after the introduction of needle-less systems [24,25]. These increased rates may have been caused by inappropriate handling of the needle-less connection system. Because of these uncertainties the use of needle-less systems is not recommended until well designed trials have proved their safety in clinical practice.

New catheters and cuffs

A silver-impregnated tissue interface barrier has been developed, to prevent migration of microorganisms from the skin surrounding the insertion site along the catheter surface to the tip. It consists of a detachable, biodegradable collagen cuff with silver ion (VitaCuff, Vitafore Corporation, San Carlos, California, USA). The cuff can be attached to a central vascular catheter and is placed just below the skin. Subcutaneous tissue rapidly grows into the collagen matrix, creating a mechanical barrier against migrating microorganisms. This mechanical barrier is enforced by a chemical (silver ion) barrier. Several studies found a short-term reduction of the intravascular catheter-related bloodstream infection rate using this device [26,27]. However, when the duration of catheterization was

more than two weeks no protective effect of the cuff was found [28,29]. This is probably due to the increasing importance of endoluminal contamination when the duration of catheterization increases [23]. The extraluminal cuff cannot protect against the endoluminal (i.e. the hub) route. More recent developments have been aimed at the prevention of adherence to the catheter material by using various materials. Both antiseptics and antibiotics have been incorporated in the catheter surface. Catheters coated with a combination of minocyclin and rifampin resulted in a decreased catheter colonization rate and a decreased catheter-related BSI rate [30]. However, the widespread use of these catheters is not recommended because of the risk of development of resistance to these valuable antibiotics. A catheter impregnated with silver sulfadiazine and chlorhexidine (Arrowgard; Arrow International, Reading, Pennsylvania, USA) also showed a significant reduction of catheter-related bacteremia in two studies. Further studies showed that with prolonged duration of catheterization the effect disappeared [16]. Further promising developments are to be expected from using new catheter materials which are less prone to adherence by microorganisms or by modifying existing materials.

Table 1 Measures for the prevention of intravascular catheter-related bloodstream infections

Measure
• insertion in the subclavian vein has the lowest infection rate*
• maximal barrier precautions should be taken during insertion
• aseptic handling of the insertion site and of the hub is mandatory
• IV teams are associated with significant reduction of the infection rate
• for skin antisepsis a mixture of povidone iodine with alcohol or chlorhexidine with alcohol is preferable
• routine changing of central vascular catheters is not effective, except for Swan–Ganz pulmonary artery catheters (interval five days)
• routine changing of the intravenous tubing set is safe at 72 hour intervals, except when blood or blood products and lipid emulsions have been used, then the interval is 24 hours
• a tissue-interface barrier (Vitacuff) has a short-term effect
• impregnation of the catheter with silver sulfadiazine and chlorhexidine has a short-term effect
• coating of the catheter with antibiotics is effective but is not recommended due to the danger of development of resistance
• new hub design aimed at reduced contamination was effective in a high incidence setting and should be investigated in low incidence settings
• the safety of needleless connecting devices has not been demonstrated yet

*Other non-infectious complications should be considered as well.

CONCLUSIONS

Certainly, advances have been made over the past decades which have made intravascular therapy and intravascular support safer for the patients. The infusate used to be a serious problem, which has largely been solved. Despite these efforts catheter-related bacteremia remains a relatively frequent and serious problem which deserves our ongoing attention. Many measures have been studied to further reduce the intravascular catheter-related bloodstream infection rate. Some measures have proven their value repeatedly, some have been shown to be of little or no effect at all. Unfortunately, most measures have shown conflicting results and their value is still uncertain. This causes undesirable differences in local protocols. In Table 1 the measures which have proven their value are summarized. The classification 'proven' does not mean that there is no doubt left about the value of the specific item. On each specific measure there are only a few studies performed. In these studies the effect was statistically significant, which does not guarantee the same effect in other settings. Therefore, it should be realized that these recommendations may change in the future. These proposed 'changes' would implicitly mean that more well designed studies have been performed in the field of intravascular catheter-related bloodstream infection, studies which should be encouraged, considering the importance of this iatrogenic and largely preventable disease.

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